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LIGHTSAT OPERATIONAL CONTROL: WHO'S IN CHARGE?

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Departments of the Navy or the Air Force.

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Theater commanders have a requirement for dedicated, responsive space systems. LIGHTSAT programs are designing their systems to satisfy this requirement. However, the military has done little to resolve the question of LIGHTSAT control responsibility. This paper does not argue the need for LIGHTSATs. Rather it assumes LIGHTSATs will be part of the military's future arsenal. This paper addresses the extent of control the warfighting CINC should have over LIGHTSATs. The resulting concept is a combination of OPCON, TACON, and Supporting Force configurations that offers a practical approach to satisfy the commander's requirement.

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LIGHTSAT OPERATIONAL CONTROL: WHO'S IN CHARGE?

Theater commanders have a requirement for dedicated, responsive space systems. LIGHTSAT programs are designing their systems to satisfy this requirement. However, the military has done little to resolve the question of LIGHTSAT control responsibility. This paper does not argue the need for LIGHTSATs. Rather it assumes LIGHTSATs will be a part of the military's future arsenal. This paper addresses the extent of control the warfighting CINC should have over LIGHTSATs. The resulting concept is a combination of OPCON, TACON, and Supporting Force configurations that offers a practical approach to satisfy the commander's requirement.

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CHAPTER I

INTRODUCTION

Military personnel have always understood the advantage of occupying the "high ground". In today's wartime environment the "high ground" is in space. A decade or two ago support from space was a novelty on the battlefield, but today "commanders have come to regard space systems ... as organic to the fray, undeniably integral to forces and weapons." (7:33) The majority of military space systems in use today are designed to support decision-makers at the strategic and national level not the operational level occupied by the warfighting Commander-in-Chief (CINC). Although many of these space systems are now supporting CINCs as secondary missions, they are centrally controlled, exist in limited numbers, and must be time-shared with a multitude of users. Every commander would like to control the assets that could make the difference between victory and defeat. General Eisenhower noted, "When a battle needs the last ounce of available force, the commander must not be in the position of depending upon request and negotiating to get it." (9:54) So now new concerns are rising over control of space assets.

In an effort to provide CINCs with dedicated space assets a new class of military satellites emerged called LIGHTSATs. These satellites generally weigh less than 1100 pounds and cost less than $25 Million. (1:77) They are simple in design, but collectively provide one user, a CINC, with responsive support from space. However, simple does not mean unsophisticated. High technology is still a big part of the satellite. The simplicity results from limiting each satellite's mission. Small simple satellites are nothing new. Sputnik, the first man-made satellite, would fall into this category. LIGHTSATs are unique in they provide the CINC with dedicated, or possibly organic, space assets.

The Department of Defense (DOD) has worked on LIGHTSATs for the past decade. (12:84) However, they have concentrated primarily on the space segment, or satellite, letting the launch and ground segment trail behind. It wasn't until 1989 that the Defense Science Board emphasized development of a matching launch segment. (8:84) While basic system technology has progressed, the operational control concept remains unsettled. This paper addresses the issue of control of LIGHTSATs. It pits centralized CONUS-based control by a command, such as U.S. Space Command (USSPACECOM), against decentralized theater-based control by the warfighting CINC.

Chapter II provides a view of where LIGHTSATs fit into the realm of military space systems. Chapter III examines the system characteristics that will impose demands on whoever controls these assets. Chapter IV offers a control concept that gives the CINC to have a responsive space system at his/her disposal without accepting the enormous infrastructure supporting it. Then, Chapter V offers considerations for implementing the concept. Finally, Chapter VI concludes by pointing out that a LIGHTSAT control concept can be successfully structured to maximize benefits while minimizing burden.

CHAPTER II

BACKGROUND

Over the last 30 years of military space, systems tended to grow in size, complexity, and cost. (1:76) As technology advanced and more missions could be practically accomplished from space a design trade-off developed. The choice was to put each mission, or payload, on its own satellite or combine payloads onto larger spacecraft. The obvious path was to achieve economies of scale by combining payloads. Satellites grew larger requiring larger launch vehicles. "The only direction seemed to be a relentless spiral toward bigger, more expensive spacecraft." (1:76) It reached a point where the government could build relatively few of these "battlestar" class spacecraft due to fiscal constraints. At the same time the customer base for these systems grew due to increasing demands for support from operational commanders. Supply could not meet demand. Since these systems were primarily for the use of national level decision-makers "only the most critical US military units received extensive space support." (5:36) The explosion of the space shuttle "Challenger" in 1986 and other subsequent launch failures highlighted the vulnerability of the path taken toward large multimission space systems. Also attempts at space support of military actions such as Operation Just Cause, "a showcase for ... space resources" (7:32), illustrated the need for systems more responsive to the operational commander.

In the mid 1980s the Defense Advanced Research Projects Agency (DARPA) began a program to respond to this need for more operationally oriented satellites. The formal name for the project is the Advanced Space Technology Program (ASTP), but it is more commonly known as LIGHTSAT. DARPA's LIGHTSAT program is also echoed by the Navy's Special Purpose Inexpensive Satellite (SPINSAT) program and the Air Force's Tactical Satellite (TACSAT) program. Correspondingly, some of the LIGHTSAT concepts and technology spilled over into the commercial sector as witnessed by Motorola's IRIDIUM program. It will provide a world-wide cellular telephone system with 77 LIGHTSATs operating from low earth orbit.

Potential missions for military LIGHTSATs include providing the CINC with on-the-spot surveillance and reconnaissance to clear the fog of war. Others involve environmental monitoring for theater weather, seastates, and mapping purposes. LIGHTSATs can provide dedicated systems to the commander for intratheater or intertheater communications and quick reconstitution of global communications systems. Eventually they could even act as target designators and Electronic Counter Measures (ECM) platforms.

The LIGHTSAT concept is not without controversy. One misconception that spurs debate is that LIGHTSATs are inexpensive, or "CHEAPSATs". Former Secretary of the Air Force Edward "Pete" Aldridge was very cautious about LIGHTSAT programs, because their proponents originally sold them as less expensive ways to replace the larger, strategic systems. (18:60) The current Assistant Secretary of the Air Force for Space, Marty Faga, points out that LIGHTSATs are no substitute for national systems. (7:34) In fact, due to reduced design reliability, the single mission nature, and the orbital placement of LIGHTSATs, economies gained by the larger, multimission systems are lost. "Realistic cost studies [show] that LIGHTSAT systems would be more expensive than existing large satellite systems, with inherently less performance, availability, and survivability." (12:84) Yet, LIGHTSATs still offer a solution to the operational need for dedicated satellite support.

Another point of contention, the topic of this paper, is: who will control LIGHTSATs? "Army officials have suggested that [LIGHTSATs] could place space assets under direct control of theater commanders." (18:60) However, many worry about "the potential problems involving commanders [being] too much in the satellite loop." (17:926)

CHAPTER III

CHARACTERISTICS AFFECTING OPERATIONS

Calvin Coolidge once asked, "Why can't they buy just one airplane and take turns flying it?" (23:23) President Coolidge was not dimwitted. Instead he lacked a basic understanding of the nature of flight and airplanes. Any commander that asks for control of space assets must be sure he/she understands the nature of LIGHTSAT systems. By understanding the demands of LIGHTSATs we can better judge the practicality of assigning responsibility for command & control to either USSPACECOM or the warfighting CINC. Any space system can generally be thought of as consisting of three segments: space, launch, and ground. Each has significant impacts on command and control.

Space Segment

In the space segment (the satellite) there are two major subsystems: the bus and the payload. The bus is the spacecraft structure as well as power, thermal, attitude control, maneuver, and communication subsystems which support the payload. The payload is that portion of the satellite tasked with performing the satellite's mission through antennae, sensors, transmitters, processors, etc. One bus can, as in the case of the larger satellites, support more than one payload, or mission. The current baseline for LIGHTSATs is one payload per bus. This baseline should mean simpler satellites to control, but it also means more satellites will be necessary to satisfy all the commander's needs. For instance, eight large UHF Follow-On (UFO) satellites will provide the military with full global communications coverage in the UHF frequency range. However, it would require 240 LIGHTSATs to provide the same geographic and frequency capability due to lower orbits and reduced payload capacity of each LIGHTSAT. (12:84) Although this is probably an extreme example, it serves to illustrate an inherent LIGHTSAT feature: large numbers of spacecraft. It then follows: the more satellites the more complex the command & control resource allocation problem.

Another LIGHTSAT design feature affecting command & control is reliability. Since the various LIGHTSAT programs are leaning toward multiple satellites of limited duration, they have consciously sacrificed reliability to hold cost and weight down. Nevertheless, when a satellite fails it is usually not a total failure, but rather a degradation in performance. There is still some portion of its mission functioning. Unfortunately, this degraded satellite will now require more "care & feeding" than its healthy brothers and sisters severely complicating the command & control process.

Launch Segment

The launch vehicle, which constitutes the most significant portion of the launch segment, must also concern the operational commander if he/she wants total control. If the satellite operators will launch the vehicle from within the theater then the commander must be prepared to establish and support the necessary launch infrastructure and accept its impact on his/her command & control system.

DARPA will provide standardized launch vehicles for use with LIGHTSATs. Table I shows their capability. The Scout is an older rocket that requires an existing launch facility and extensive launch preparation. The Pegasus, Taurus, and Enhanced Taurus are unique in that they will not need existing launch pads. The Pegasus will drop from the wing of a B-52 and will be ready to launch within 36 hours notice. (2:79) The Taurus will launch larger spacecraft from unimproved areas within 8 days notice. (2:79)

TABLE I
LIGHTSAT Launch Vehicles

	PEGASUS	SCOUT	TAURUS	ENHANCED TAURUS
PAYLOAD TO 400 nmi CIRCULAR	400 LBS	322 LBS	1000 LBS	2300 LBS
COST ($M)	$6.2	$12-$15	$12-$15	$15

Source: James W. Rawles, "A Big Boost For LIGHTSATs?", Defense Electronics, March 1990, p. 62.

The ability to launch a satellite means more than lighting the fuse and letting the rocket blast off. It also requires downrange tracking and a number of days of on-orbit checkout, or testing, before it is an operational system. Therefore, a command & control system must be robust enough to have connectivity with tracking facilities outside the theater. It must also be flexible enough to perform launch, ascent, and checkout operations while continuing to support other satellites already in orbit.

Ground Segment

While the launch segment is important, it actually plays a transitory role. The ground segment is the heart of space system command & control. The first consideration for this segment is mobility. As with all the elements of command & control a CINC has at his/her disposal, mobility offers increased survivability and flexibility by moving with the forces it supports. But flexibility is a two-edge sword. The flexibility associated with mobile ground command & control centers limits the flexibility of the space segment and vice versa. As a satellite adds flexibility, the command & control system on the ground must add complexity and size. This applies to space segment flexibility through individual satellite design and also through increased numbers of satellites. Designers and operators often overlook this inverse relationship.

LIGHTSAT programs typically choose the numerous, simple satellite approach to introduce flexibility. The sheer numbers involved pose a formidable challenge to the ground segment. Scheduling a finite number of computers, antennas, etc. to support a large number of satellites is a massive problem. Today Air Force Space Command supports somewhere under 100 satellites with approximately 15 ground antennas. Their scheduling process starts two weeks in advance and schedulers modify the plan constantly up until each ground antenna makes contact with its appointed satellite. We've already seen that a single multimissioned system requires up to 30 times the number of LIGHTSATs to replace it. So whoever takes control of LIGHTSATs will have a major obstacle to overcome in scheduling resources.

The preceding discussion shows there is more to a LIGHTSAT space system than just a satellite. An operations concept should consider the trade-off between benefits of direct control and the disadvantage of accommodating the LIGHTSAT infrastructure.

CHAPTER IV

THE CONCEPT

Some experts see Navy LIGHTSATs being controlled directly from the carrier task force. (5:39) Yet others fear giving commanders too much control could cause more confusion than coherence to combat forces. (6:13) How much control is enough and how much is too much? The key is to remember the real requirement. The requirement is not for control of satellites. Instead, the requirement is for space systems that are responsive to the time critical needs of the CINCs. After visiting several CINCs, Major General O'Berry of Air Force Space Command said, "No one has said give me OPCON [Operational Control]." (21:2) Today national space systems respond to a CINC as one of many requesting users with a given priority. These systems act as "Supporting Forces" to the CINC (per JCS Pub 0-2). LIGHTSATs, however, are predicated on providing systems that respond directly to a single CINC. The proposed concept, outlined in Table II and Figure 1, will make LIGHTSATs directly responsive without overburdening the CINC with the additional Operational Control (OPCON) or Combat Command (COCOM) responsibilities.

Launch

The first question with respect to control of the launch segment is location. An out-of-theater launch offers enormous benefits. Some might argue launching a LIGHTSAT in-theater is the same as launching a Pershing tactical missile. This is untrue. The Pershing is an intratheater ballistic missile. A LIGHTSAT will orbit the entire earth requiring support while outside the theater. Additionally, the LIGHTSAT rocket is larger and more complex than a Pershing. There is nothing in orbital

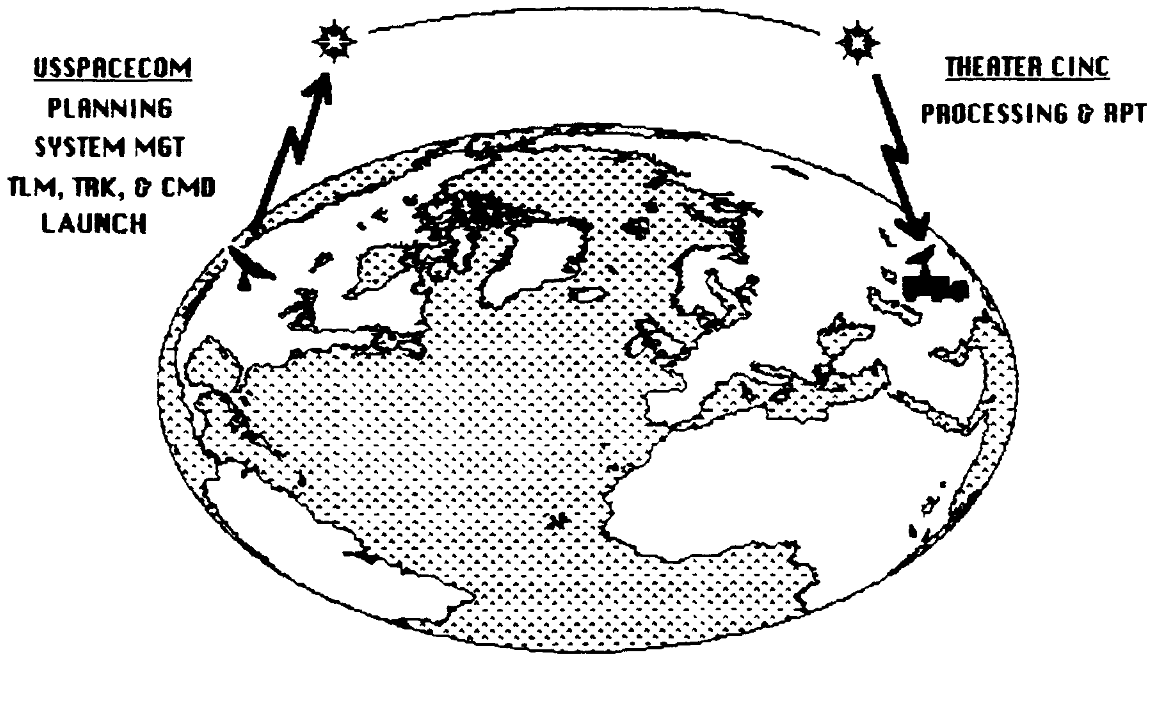
TABLE II

LIGHTSAT CONTROL CONCEPT

	LAUNCH SEGMENT	GROUND SEGMENT			
		PLANNING	SYSTEM MANAGEMENT	TELEMETRY TRACKING & COMMANDING	PROCESSING & REPORTING
CINC	SUPPORTED	TACON	TACON	TACON	OPCON
USSPACECOM	SUPPORTING	COCOM/OPCON			NONE

FIGURE 1

LIGHTSAT OPERATIONS CONCEPT



mechanics that demands an in-theater launch. In fact, this is a disadvantage. If the theater were at northern latitudes and the mission of the LIGHTSAT called for a low inclination, like equatorial, the LIGHTSAT booster could not achieve that orbit launching from within the theater. On the other hand, a Pegasus flying on a B-52 out of U.S. owned Guam or Jarvis Island on the equator could launch directly into an orbit of any inclination.

Another consideration is logistics. Although the launch system will not require special launch facilities, getting the satellite, booster, aerospace ground equipment (AGE), and launch personnel into the theater will displace air/sea lift capacity better used for terrestrial systems like beans, bullets, and soldiers. The LIGHTSAT booster bare-base concept really addresses the vulnerabilities and restrictions of our two permanent launch facilities in Florida and California rather than the concept of in-theater launch.

The logical concept is to assign a USSPACECOM LIGHTSAT launch team to the warfighting CINC as a Supporting Force. The CINC or National Command Authority would most likely make the decision to launch a LIGHTSAT prior to the outbreak of hostilities, because the time required to launch and checkout a LIGHTSAT will be in terms of days or weeks. Thus, immediate wartime responsiveness is not as large an issue for the launch segment as compared to the time critical control exercised by the ground segment. This arrangement is analogous to U.S. Transportation Command (USTRANSCOM) operating their airlift and sealift resources as a Supporting Force deploying assets for Central Command (CENTCOM) in the Gulf War. In this case, USSPACECOM will operate their spacelift resources as a Supporting Force deploying space assets for a CINC.

Ground

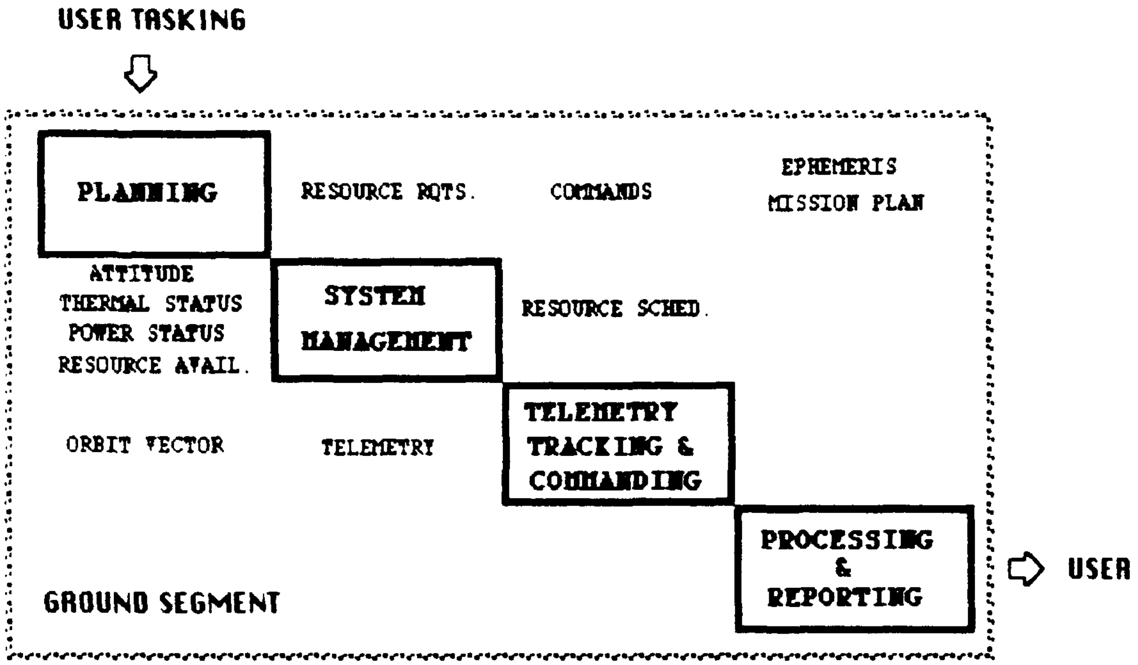
While the control of the launch segment is fairly straight forward, ground segment control is not. The launch segment deploys the space system. The ground segment employs it and, therefore, is a critical element in satisfying the responsiveness requirement. To distinguish the LIGHTSAT control concept from the existing Supporting Force concept used by national systems we must examine the ground segment through each of its major functional elements. Taking a surveillance mission as an example, the ground segment functions would consist of: planning; system management; telemetry, tracking & commanding (TT&C); and processing & reporting.

The first function, planning, turns the user's request, or tasking, into satellite commands. The system management function is responsible for monitoring the health and status of the satellite and scheduling ground support resources. The TT&C function transmits the commands to the satellite, recovers telemetry, and gathers tracking data to determine and predict the satellite's location. Finally, the processing & reporting function takes the payload collected data, processes it, and passes it to the user. Figure 2 illustrates the relationship between these functions.

In some sense it would be useful to have all four functions performed at the same location. For many national systems, like the Defense Meterological Support Program (DMSP), this is essentially true. DMSP operators perform all four functions from Offutt AFB, plus they are co-located with their primary user, the Strategic Air Command (SAC). In most cases, however, the user is not co-located with the ground

FIGURE 2

INTERRELATIONSHIP OF GROUND FUNCTIONS



KEY: VERTICAL = INPUT; HORIZONTAL = OUTPUT

segment. This slows response time. Some national systems make themselves more responsive to theater commanders by giving the CINCs a processing and reporting capability. The DMSP Interactive Tactical Terminal is a prime example. (3:6.1) The CINC's forces enter the theater with these terminals so they can access weather data coming directly from a DMSP satellite. The CINC has OPCON of these processing & reporting systems. This means the CINC has full authority to organize, establish plans and policies, reassign officers, etc. to accomplish his/her mission. (11:3.16) For LIGHTSATs this should not change. There is nothing more responsive than a satellite transmitting its data directly to the user equipped with his/her own processing & reporting capability. Therefore, the CINC should have OPCON of the processing & reporting function of LIGHTSATs.

It would also be tempting to place the planning function with the CINC. Afterall, the planning function is the only one that communicates with the user and the processing & reporting function. However, when examining the amount of information passed between functions in Figure 2, we find large amounts of data passing between planning, system management, and TT&C while relatively small amounts pass between the user, planning, and processing & reporting. In fact, tasking could be as simple as a telephone call or a one-line message. In keeping with the principle of economy of force, the CINC should not waste communications links for functions that are really unnecessary if control relationships are properly structured. So it is more advantageous to co-locate planning, system management, and TT&C. But where should that be?

The system management function and, to some extent, the TT&C function require numerous contacts with the satellite to do their job. To perform it well, these contacts must be spread out over the globe for better orbit accuracy, pointing accuracy, and health trend analysis. This leads to a need for access to a global network of antennas. As Chapter III pointed out, the infrastructure associated with LIGHTSATs is extensive. USSPACECOM already has an established infrastructure capable of supporting LIGHTSATs. Consequently, USSPACECOM should perform the functions of planning, system management, and TT&C. Giving the CINC OPCON of these USSPACECOM forces is not the answer. The CINC does not need to accept the tremendous burden of the organizational responsibility associated with OPCON to ensure responsive action. However, it is advantageous for the CINC to have Tactical Control (TACON) over these forces even though they may be located far outside the theater, like Colorado Springs. TACON is the key to giving the CINC a LIGHTSAT immediately responsive to his needs while leaving the COCOM/OPCON responsibility for organizing, training, and equipping the forces with USSPACECOM.

The Supporting Force configuration in place now is also not the answer. It is inherently slower than the other control categories and the warfighting CINC may get out-prioritized for support as sometimes happens with the national systems. In a Supporting Force role USSPACECOM would have "the responsibility to ascertain the needs of the supported force and take such action to fulfill them as in within existing capabilities, consistent with priorities and requirements of other assigned tasks." (11:3.19) This would permit USSPACECOM to manipulate LIGHTSATs without the warfighting CINC's consent and possibly preempt the CINC's use of his/her LIGHTSAT. This is not the most responsive configuration possible. TACON, on the other hand, will provide the CINC with "sufficient authority for controlling and directing" (11:3.17) LIGHTSATs without the burden of administrative or logistical support.

CHAPTER V

IMPLEMENTING THE CONCEPT

The key to making the proposed concept work is communication. This is true in both the technical sense of communication systems and the human factors sense of communicating intent or desire.

The communication capability between USSPACECOM and the theater CINC does not need to be extensive, but it must be available and direct. As shown in the last chapter, the information passed between USSPACECOM and the theater will not involve large or complex amounts of data. However, most LIGHTSATs, orbiting at low altitude, will not dwell over the theater and will have a limited time to execute their mission. For instance, a satellite at an altitude of 400 nmi. passing directly overhead (the best possible geometry) is visible for only 15 minutes. Thus, an available, direct communications link is imperative to speed planning and execution. This link should patch the CINC's headquarters with the USSPACECOM operational unit bypassing all intermediate headquarters. Only then can LIGHTSATs fully realize their responsiveness potential.

Once the CINC and USSPACECOM establish the technical communications link, they must insure a human communications link exists. The theater CINC must make his/her staff space savvy. General Dugan, while US Air Forces in Europe commander, had the right idea when "he asked Air Force Space Command to send him specialists to educate his ... planners and operators ... in space systems ...." (6:12) However, what Gen. Dugan started needs to go a step further. Unified commanders must follow suit. Also they must incorporate career space operators into the plans and operations portions of their staffs. This space cadre would make LIGHTSATs an integral part of peacetime planning and act as a joint force space element during times of armed conflict. In this latter role, they would sort the needs of the tactical commanders along with the CINC's own requirements and communicate them as tasking requests to USSPACECOM.

At the same time, USSPACECOM must organize in such a way to expedite the tasking-to-execution process. Some options include a separate LIGHTSAT satellite control wing, or group, where USSPACECOM dedicates each squadron to a CINC or where they dedicate each squadron to a particular LIGHTSAT mission for all CINCs. The advantage of a squadron dedicated to a CINC is a unit geared to respond directly to that CINC. The disadvantage is the squadron may be asked to retain expertise on too many different LIGHTSATs. Squadrons dedicated by LIGHTSAT mission solves that problem, but introduces the potential for a squadron needing to satisfy multiple CINCs. In either case, the measure should continue to be satisfaction of the original requirement: a space system responsive to the warfighting CINC.

CHAPTER VI

CONCLUSION

Warfare of the future will involve space assets in ever increasing amounts. Services are revising their doctrines to fully incorporate space into their thinking. Air Doctrine has become Aerospace Doctrine and the Army has recognized "the success of future joint and combined operations will depend on further development and integration of space operations with air, land, and naval operations." (22:12)

The warfighters find the current national space systems offer great benefits to the theater commander, but dedicated use of these systems is rarely guaranteed. LIGHTSATs are an attempt to give the warfighting CINC a set of dedicated space systems completely at his/her call. However, the controlling element does not need to be in-theater or under complete control (OPCON) of the CINC to be responsive. The CINC does not benefit by accepting the burden of unnecessary control responsibilities. USSPACECOM provides a space system infrastructure and organization ready to help the warfighting CINC. The CINC should use Supporting Forces of USSPACECOM for launch services and obtain TACON of the USSPACECOM forces performing LIGHTSAT planning, system management, and telemetry tracking & commanding while retaining OPCON of processing & reporting assets. This way the CINC maximizes system responsive while minimizing its complicating factors.

Thus through the appropriate application of OPCON, TACON, and Supporting Force designations, LIGHTSATs can achieve their goal: space systems dedicated and responsive to warfighting CINCs.

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